PHYSICS I: An Outline

Chap 1. Introduction

1. Significant Figures
2. Units (SI, British)

Chap 2. Kinematics -1D

1. Average, Instantaneous
2. Displacement, Velocity, Acceleration, Derivatives
   $\bar{v} = \frac{\Delta x}{\Delta t},\ v = \frac{dv}{dt}$
3. Uniform Acceleration
   $v = v_0 + at$
   $x = x_0 + \bar{v}t,\ \bar{v} = \frac{1}{2}(v + v_0)$,
   $v^2 = v_0^2 + 2a(x - x_0)$,
   $x = x_0 + v_0 t + \frac{1}{2}at^2$.
4. Falling Bodies $a = -g$.

Chap 3. Vectors

1. Vectors and Scalars:
   $\mathbf{V} = V_x\mathbf{i} + V_y\mathbf{j} + V_z\mathbf{k}$
2. Addition, Scalar Multiplication, Length
3. Components
   $V_x = V\cos\theta,\ V_y = V\sin\theta$.
   $V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{Vy}{Vx}$.

Chap 4. Kinematics - 2D-#D

1. Displacement, Velocity, Acceleration
2. Projectile Motion
   $a_x = 0,\ a_y = -g\quad g = 9.8$ m/s
3. Circular Motion: Uniform
   $a_R = \frac{v^2}{r},\ T = \frac{2\pi r}{v}$, $f = \frac{1}{T}$
   Nonuniform: $a_T = \frac{dv}{dt}$

Chap 5. Force and Motion I

1. Law of Inertia
2. $\mathbf{F}_{net} = m\mathbf{a}$
3. Action-Reaction
4. Weight, Normal Force, Tension $W = mg,\ N, T$
5. Free Body Diagrams

Chap 6. Force and Motion II

1. Friction $f = \mu_s N$
2. Circular Motion
   $a_R = \frac{v^2}{r}, F = ma_c$
3. Unbanked Curves
   $v = \sqrt{\mu_s gr}$
4. Banked Curve $\tan\theta = \frac{v^2}{rg}$

Chap 7. Work and Energy

1. $W = \mathbf{F}\cdot\mathbf{d} = Fd\cos\theta$
2. $W = \int_a^b \mathbf{F}\cdot d\mathbf{l}$
3. $W = \Delta K,\ K = \frac{1}{2}mv^2$
4. Hooke's Law $F = -kx$
5. Power
   $\bar{P} = \frac{W}{t},\ P = \frac{dW}{dt} = \mathbf{F}\cdot\mathbf{v}$

Chap 8. Energy Conservation

1. $U = mgy$ (gravitation),
   $U = \frac{1}{2}kx^2$ (spring)
2. $\Delta U = -\int_1^2 \mathbf{F}\cdot d\mathbf{l},\ F = -\frac{dU}{dx}$
3. Conservation of Energy:
   $E = \frac{1}{2}mv^2 + U$

Chap 9. Linear Momentum

1. Center of Mass:
   $\mathbf{r}_{com} = \frac{1}{M}\Sigma m_i\mathbf{r}_i$,
   $\mathbf{r}_{com} = \frac{1}{M}\int \mathbf{r}\, dm$
2. Momentum $\mathbf{p} = m\mathbf{v}$
   $M\mathbf{r}_{com} = \Sigma m_i\mathbf{r}_i$,
   $\mathbf{v}_{com} = \frac{1}{M}\Sigma m_i\mathbf{v}_i$,
3. $\mathbf{F}_{ext} = M\mathbf{a}_{com},\ \mathbf{F}_{ext} = \frac{d\mathbf{P}}{dt}$,
4. Momentum Conservation
5. Inelastic Collisions
6. Elastic Collisions
   $v_{1f} = \frac{m_1 - m_2}{m_1 + m_2}v_{1i}$
   $v_{1f} = \frac{2m_1}{m_1 + m_2}v_{1i}$
7. Impulse: $J = \Delta mv = F\Delta t$

Chap 10. Rotation

1. Rotational Variables
2. Kinematics
   $\omega = \omega_0 + \alpha t$,
   $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$,
   $\omega^2 = \omega_0^2 + 2\alpha\theta$
3. $\omega = \frac{d\theta}{dt},\ \alpha = \frac{d\omega}{dt}$
4. Torque: $\boldsymbol{\tau} = \mathbf{r}\times\mathbf{F} = I\boldsymbol{\alpha}$.
5. Moment of Inertia
   $I = mr^2$, (particle) and rod, sphere, cylinder
6. Kinetic Energy $K = \frac{1}{2}I\omega^2$
7. Parallel Axis Theorem
   $I = I_{com} + Mh^2$

Chap 11. Angular Momentum

1. Rolling without Slipping
   $v_{com} = \omega r$
2. Angular Momentum:
   $\mathbf{L} = \mathbf{r}\times\mathbf{p},\ L = I\omega,\ \boldsymbol{\tau}_{net} = \frac{d\mathbf{L}}{dt}$
3. Conservation Law $L_i = L_f$
4. $K_{total} = K_{rot} + K_{trans}$
   (Rolling Sphere = $\frac{7}{10}mv^2$)

Chap 12. Equilibrium and Elasticity

1. $\Sigma\mathbf{F} = 0,\ \Sigma\boldsymbol{\tau} = 0$
2. Center of Gravity
3. Stress$\propto$Strain, $\frac{F}{A} = E\frac{\Delta L}{L}$
4. Linear, Shear, Bulk

Chap 13. Gravitation

1. $F = \frac{Gm_1m_2}{r^2},\ g = \frac{GM}{R^2}$
2. $U = -\frac{GMm}{r}$
3. Satellites $v = \sqrt{\frac{GM}{r}}$
4. Kepler's Laws of Motion
   (3rd $\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$**)**

Chap 14. Fluids

1. $m = \rho V,\ p = \frac{F}{A}$
2. $p = p_0 + \rho gh$
3. Pascal's Principle $P_o = P_i$
4. Archimedes' $B = \rho_f gV$
5. Flow Rate: $R_V = Av$
6. Continuity $A_1v_1 = A_2v_2$
7. Bernouli's Equation
   $P + \frac{1}{2}\rho v^2 + \rho gh =$ const.

Chap 15. Oscillations

1. Hooke's Law $F = -kx$
2. $m\ddot{x} + kx = 0 \Rightarrow \ddot{x} + \omega^2 x = 0$
3. $x(t) = a\sin\omega t + b\cos\omega t$,
   $x(t) = A\cos(\omega t + \phi)$
4. $\omega = \sqrt{\frac{k}{m}}$ (spring),
   $\omega = \sqrt{\frac{g}{L}}$ (pendulum)
5. Energy
   $E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$
6. Physical Pendulum
   $T = 2\pi\sqrt{\frac{I}{mgh}}$

Chap 16. Wave Motion

1. $v = \lambda f$
2. $v = \sqrt{\frac{\tau}{\mu}}$ (string)
3. $y = y_M\sin(kx \pm \omega t)$
4. $k = \frac{2\pi}{\lambda},\ \omega = \frac{2\pi}{T} = 2\pi f$
5. Superposition, reflection, refraction, interference, diffraction, resonance
6. Standing Waves - String
   $\lambda_n = \frac{2L}{n},\ n = 1, 2, \ldots$

Chap 17. Sound

1. $v = \sqrt{\frac{B}{\rho}}$, $v \approx 331 + 0.60T$
2. loudness, pitch, range
3. Intensity $I = \frac{\bar{P}}{A} \propto \{A^2, \frac{1}{r^2}\}$
4. Level: $\beta(\text{dB}) = 10\log\frac{I}{I_0}$
5. Open-Open/Closed Tubes
   $f_n = \frac{nv}{2L},\ f_n = \frac{nv}{4L}$
6. Beats $f_{beat} = \nabla f$
7. Doppler Effect
   $f' = f(\frac{v \pm v_D}{v \pm v_S})$ (toward - up)
8. Shock Waves $\sin\theta = \frac{v}{v_s}$

Chap 18. Temperature, Thermal Expansion and the Ideal Gas Law

1. Temperature Scales
2. Expansion $\Delta L = \alpha L_0\Delta T$
3. Heat Capacity, Latent Heat
   $Q = mc\nabla T,\ Q = mL$
4. Mechanical Equiv of Heat
5. $W = \int p\ dV$
6. 1st Law $U = Q - W$
7. isothermal, isobaric, isochoric, adiabatic
8. Conduction, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$
9. Convection
10. Radiation, $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$

Chap 19. Kinetic Theory

1. Molar mass
2. $PV = nRT = NkT$
3. Isothermal $W = nRT\ln\frac{V_2}{V_1}$
4. $\frac{1}{2}(mv^2)_{ave} = \frac{3}{2}kT$
   $\Rightarrow v_{rms} = \sqrt{\frac{3kT}{m}}$
5. $U = \frac{3}{2}nRT$
6. $Q = nC\nabla T$
7. $C_V = \frac{3}{2}R,\ C_P = C_V + R$
8. Adiabatic
   $pV^\gamma =$const, $\gamma = \frac{C_p}{Cv}$

Chap 20. The Second Law of Thermodynamics

1. $\varepsilon = \frac{W}{|Q_H|} = 1 - |\frac{Q_L}{Q_H}|$
2. Carnot engines
   $\varepsilon_C = 1 - \frac{T_L}{T_H}$
3. Kelvin-Planck, Clausius
4. $\oint\frac{dQ}{T} = 0$ (reversible)
5. Entropy: $dS = \frac{dQ}{T}$
6. $\Delta S > 0$
7. $S = k\ln W$

Miscellaneous Constants

$G = 6.67\times10^{-11}$ Nm²/kg²
$N_A = 6.02\times10^{23}$ mol^{-1}
$R = 8.315$ J/(mol-K)
$k = 1.38\times10^{-23}$ J/K
$\sigma = 5.67\times10^{-8}$ W/(m^2-K^4)
1 cal= 4.186 J
1 atm $= 1.013 * 10^5$ Pa
$L_f = 80$ cal/g, $L_v = 540$ cal/g
$\rho_{water} = 1.0 * 10^3$ kg/m^3
$v_{air} = 331$ m/s (0°C)
$I_0 = 1.0\times10^{-12}$ W/m^2
$c_{water} = 1.0$ kcal/(kg-°C)